# BTeV Muon (WBS 1.5)

Paul Sheldon ~ Vanderbilt University

- Institutions
- Requirements
- Design
- Project Management
- Costs and Labor
- Schedule and Major Milestones
- FY05 Activities
- Concluding Remarks

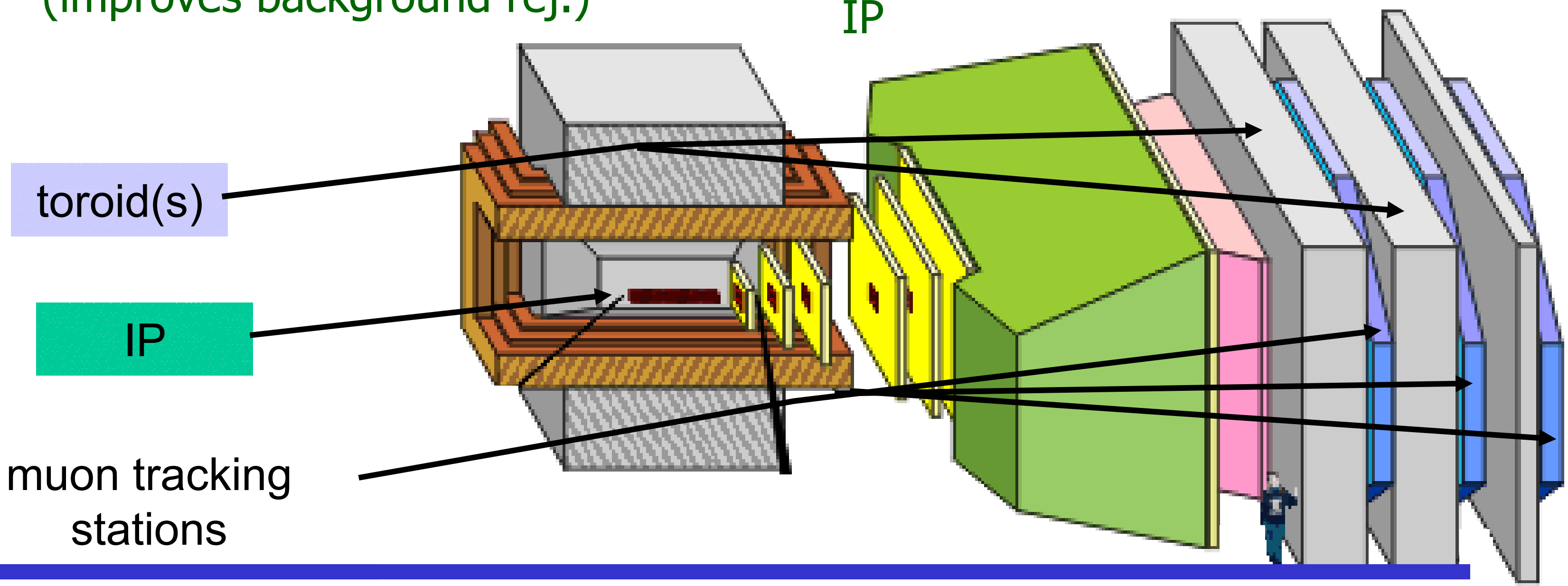
# Institutions & People

- **Illinois**
  - Mike Haney
  - Vaidas Simaitas
  - Mats Selen
  - Jim Wiss
  - Doris Kim
- **Puerto Rico**
  - Angel Lopez
  - Hector Mendez
  - Eduardo Ramirez
  - Zhong Chao Li
  - Aldo Acosta
- **Vanderbilt**
  - Will Johns
  - Paul Sheldon
  - Med Webster
  - Eric Vaandering
  - John Fellenstein

**Legend:**
Engineer
Faculty
PostDoc
Technical

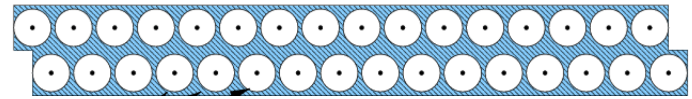
# Goals & Constraints

- Provides Muon ID and Trigger
  - Trigger & ID for interesting physics states
  - Check/debug pixel trigger
- Fine-Grained tracking + toroids
  - Stand-alone mom./mass trig.
  - Momentum "confirmation" (improves background rej.)
- Requirements & Characteristics
  - 2 mm position resolution
  - Trigger: 500:1 min bias rejection, 80% efficiency for di-muon events
  - 200 mrad maximum acceptance (set by size of hall), 40 mrad minimum (set by beam components)
  - Stations at 9.4, 10.8, & 12 m from IP

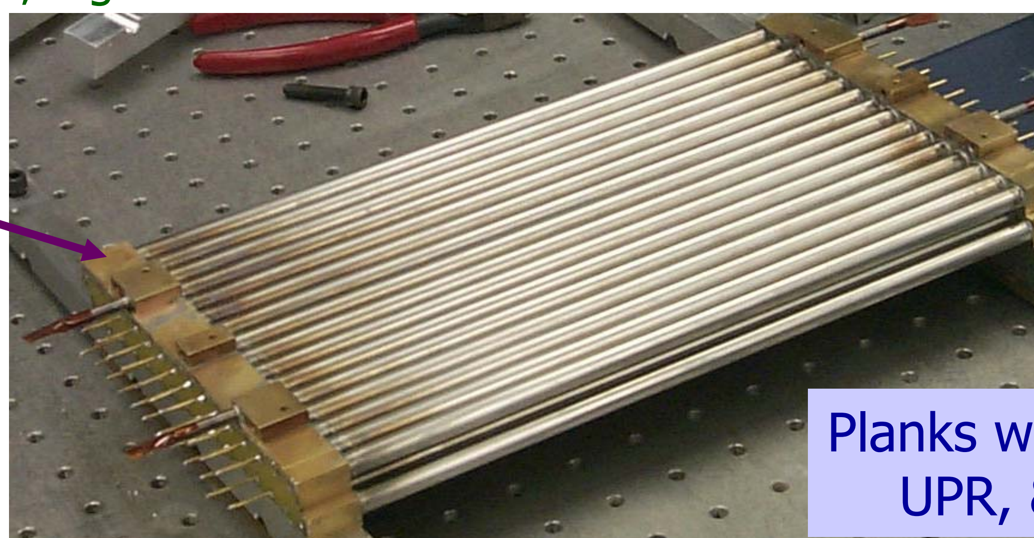


# Basic Building Block

- Basic Building Block: Proportional Tube "Planks"
  - 3/8" diameter Stainless steel tubes (0.01" walls)
  - "picket fence" design



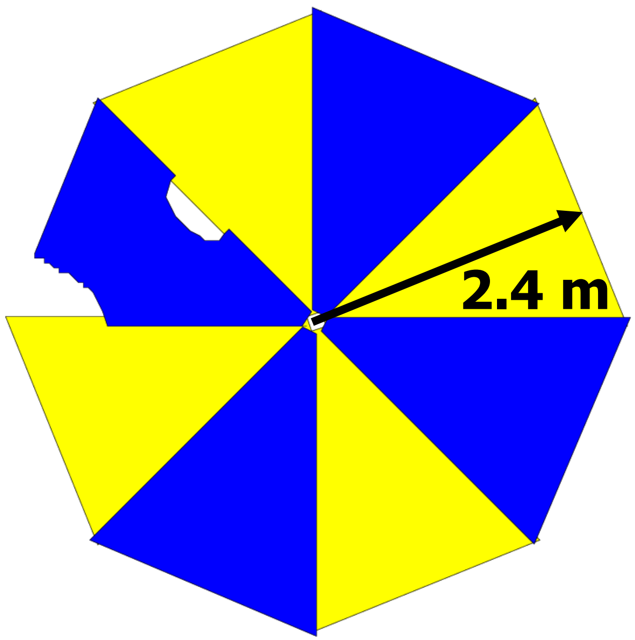
  - 30μ (diameter) gold-plated tungsten wire
  - Brass gas manifolds at each end (RF shielding important!)
  - Front-end electronics: use Penn ASDQ chips, modified CDF COT card
  - Likely to use 85% Ar - 15% $CO_2$ (no $CF_4$)
  - Robust, high-rate detector element



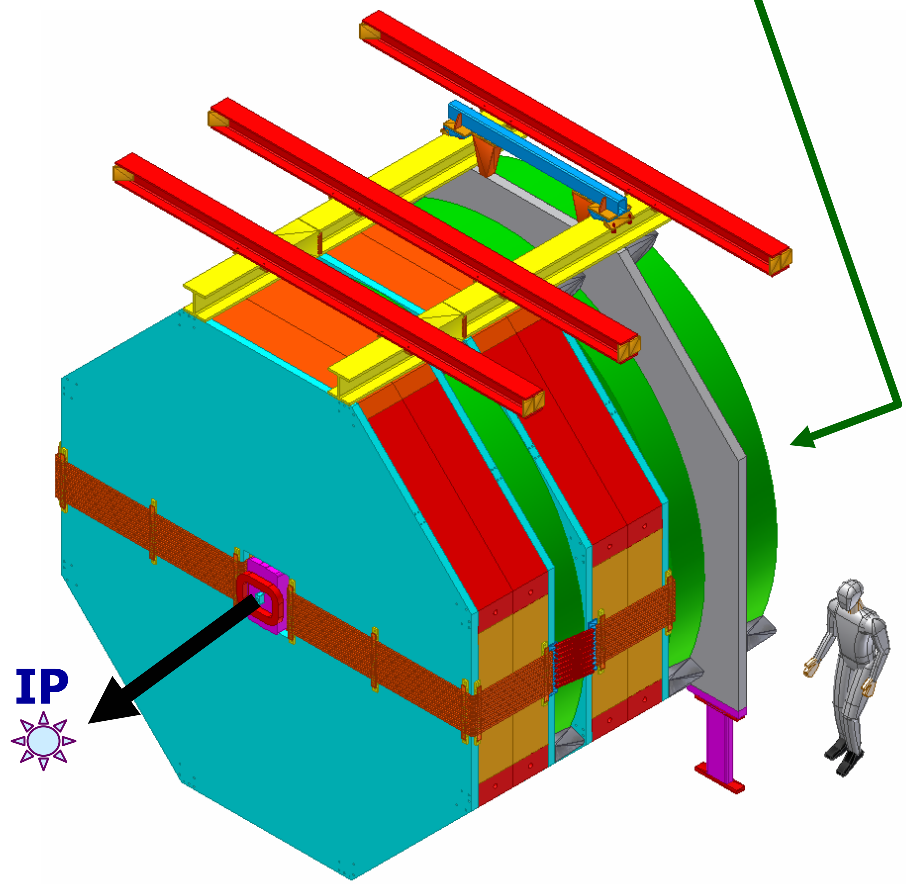
Planks will be built at UI, UPR, & VU (527 ea)

# Geometry

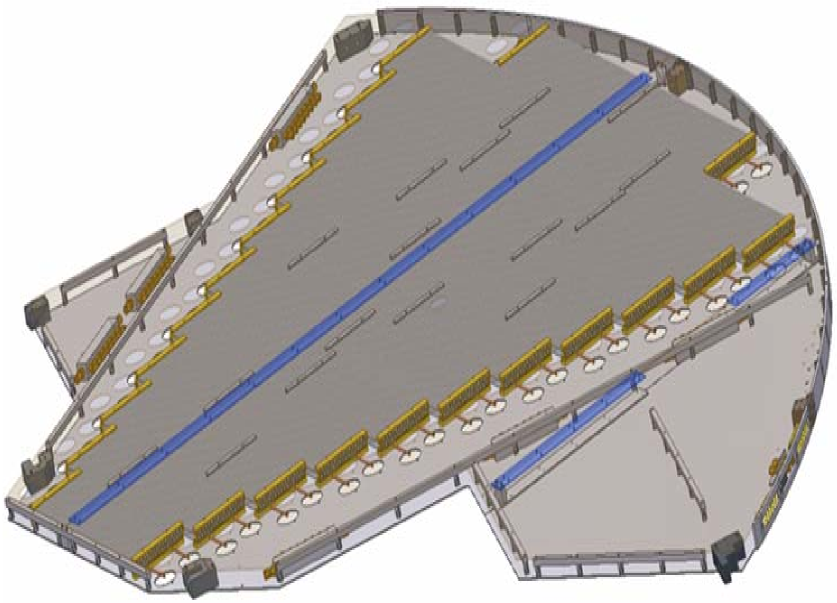
- We want to observe tracks in 3 disk shaped ***stations*** 2.4 m in radius:
  - Minimum pattern recognition confusion
  - Minimize occupancy and distribute it uniformly

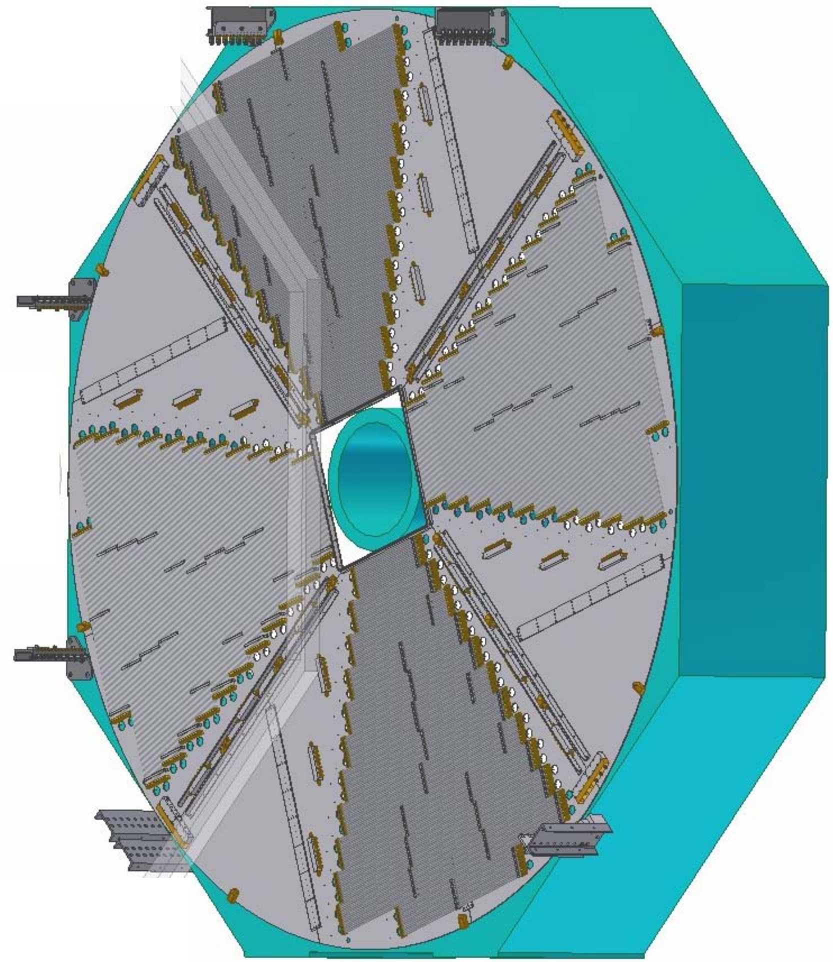



**Beams Eye View of each station:** divided into overlapping ***octants***



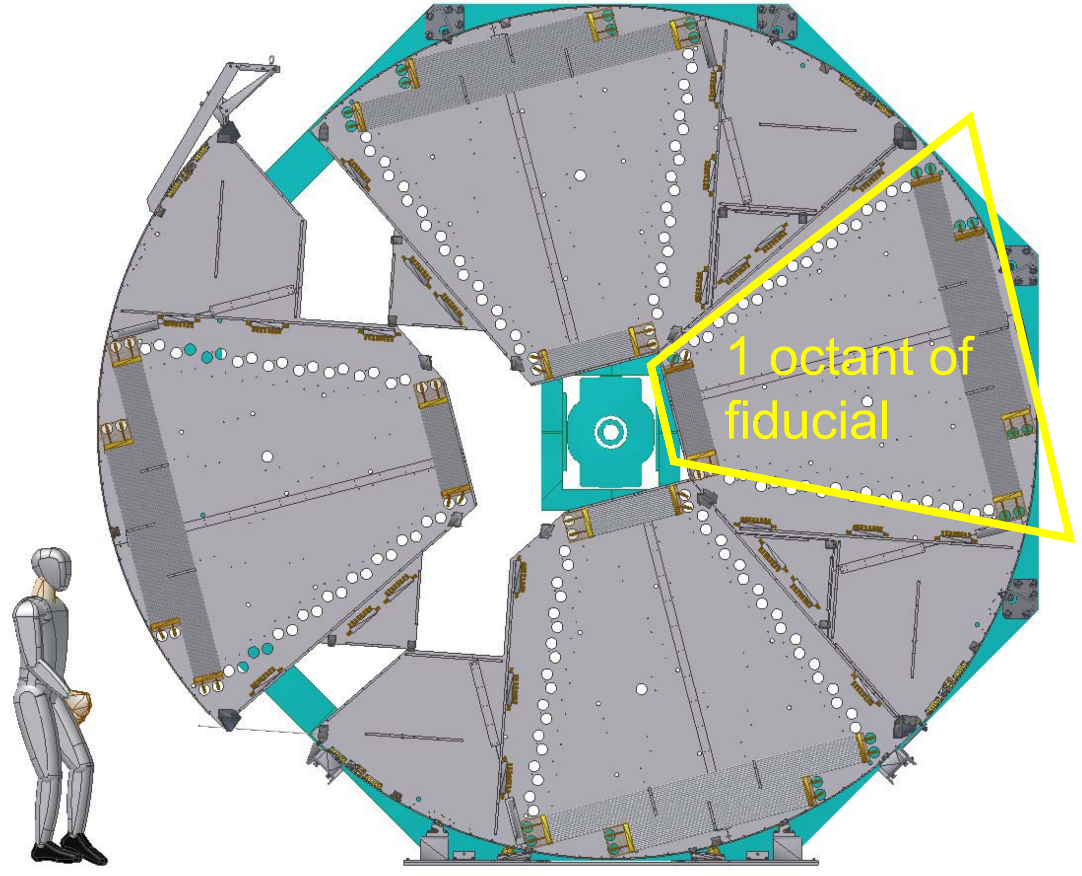
# Cover Each Octant Shaped Region with Planks





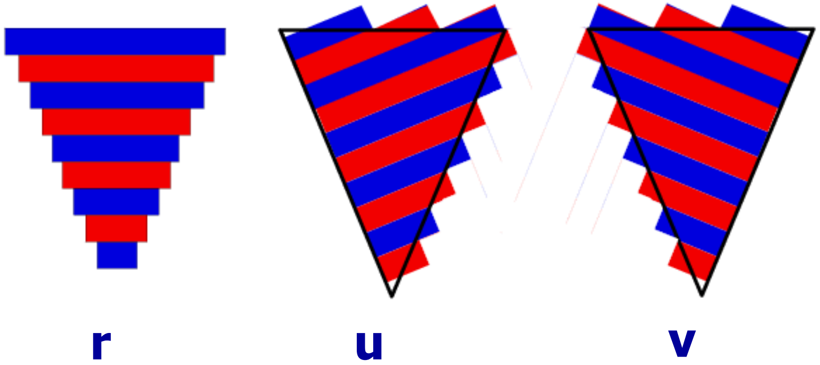
- 4 ***octants*** or ***quads*** make a ***wheel***
- two ***wheels*** are required for full azimuthal coverage.
- Short planks at small radius minimize occupancy there.
- Octant geometry minimizes pattern recognition confusion

# Muon Wheel

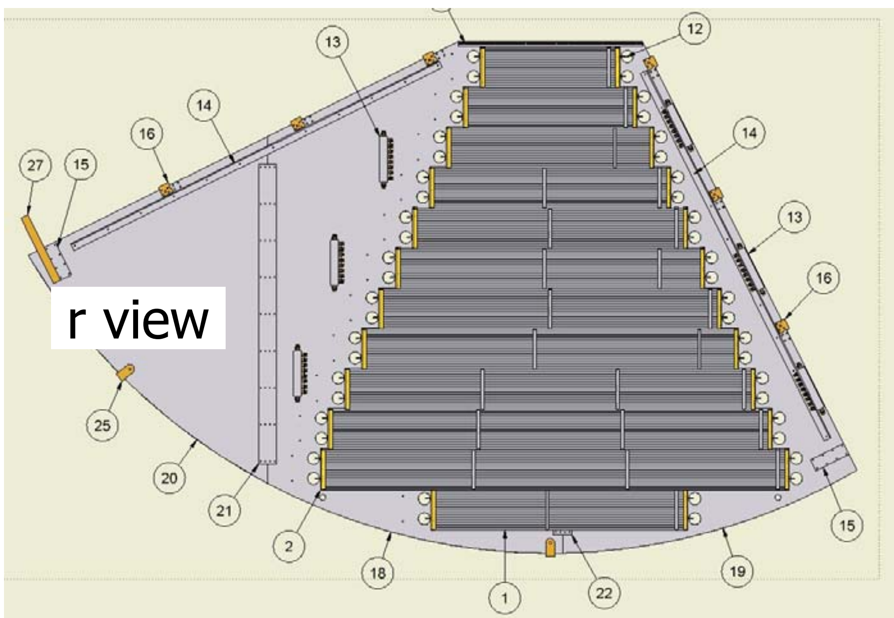


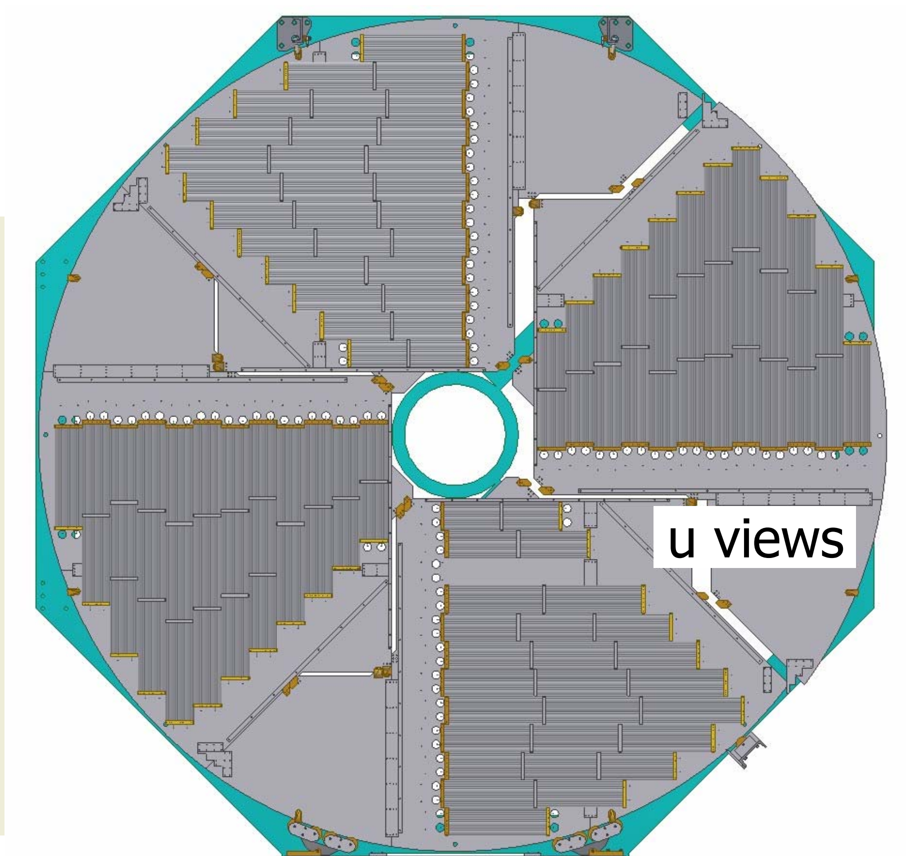

# Stereo and Radial Views

**12 planks "cover" each octant**



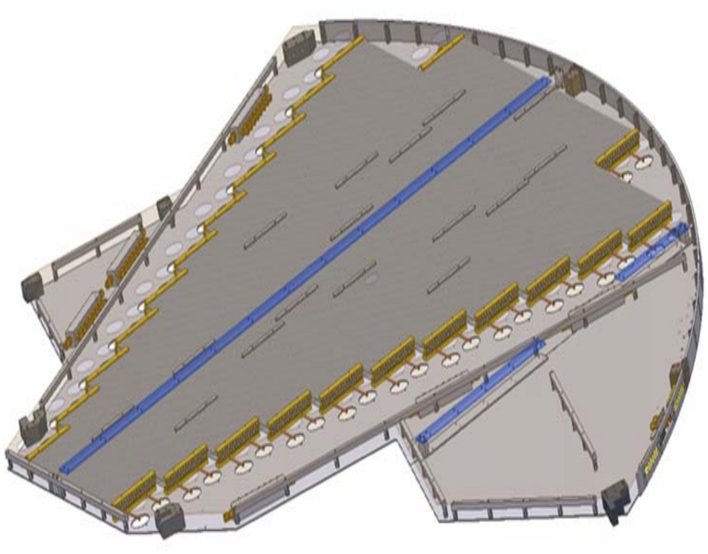

**2 stereo views provide $\phi$ info.**
**4 views per station (r, u, v, r)**
**8 wheels per station**



# Installation Unit: the Octant (or Quad)

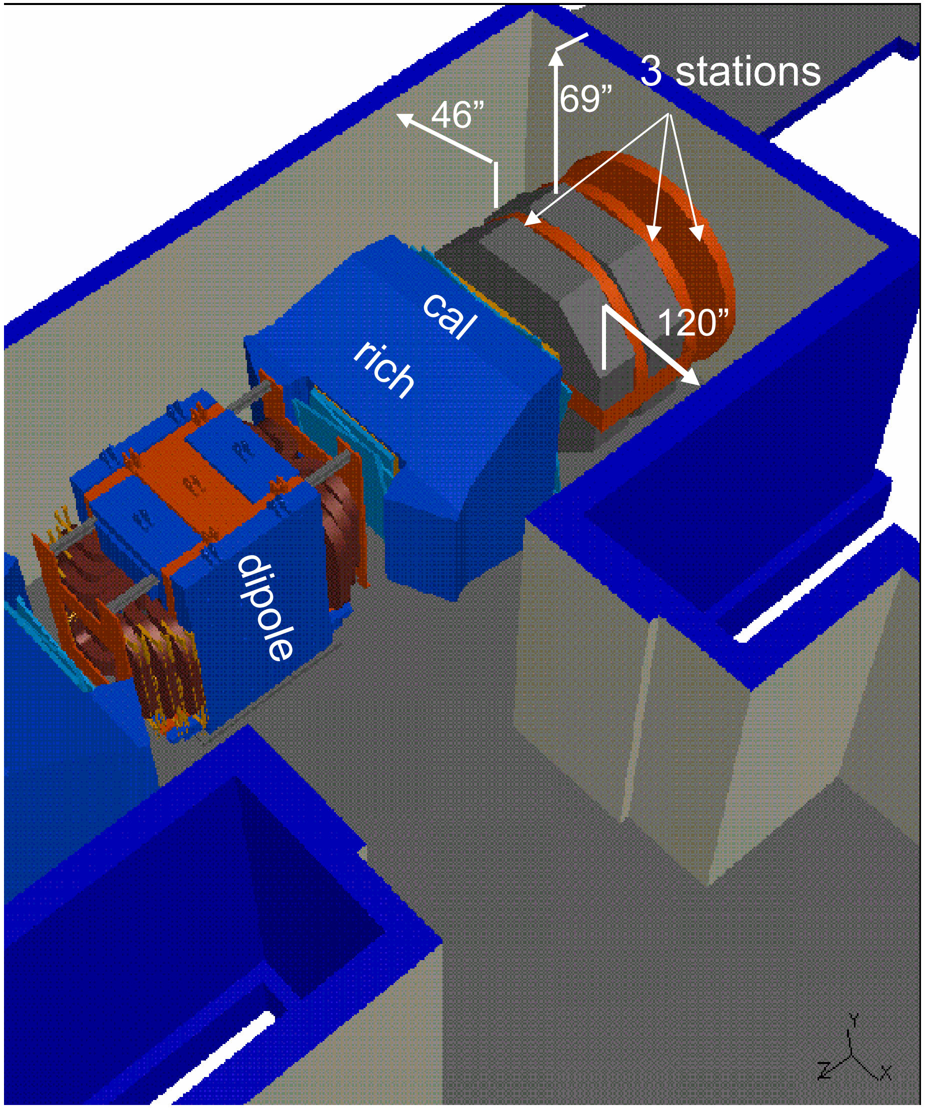
- Planks are mounted on an "exoskeleton" made of **100 mil** thick aluminum plates and stiffener bars
- Octants built at UI and VU and sent to FNAL.
- Top cover plate not shown!



- At **300 lbs.**, octants are light and small enough that handling them is relatively easy.

# Prototype Wheel at UI

# Installation




- The small size of the hall gives us little room above or on one side of the detector.
- There is no overhead crane in the hall.
- This has forced us to be creative in designing our installation scheme!

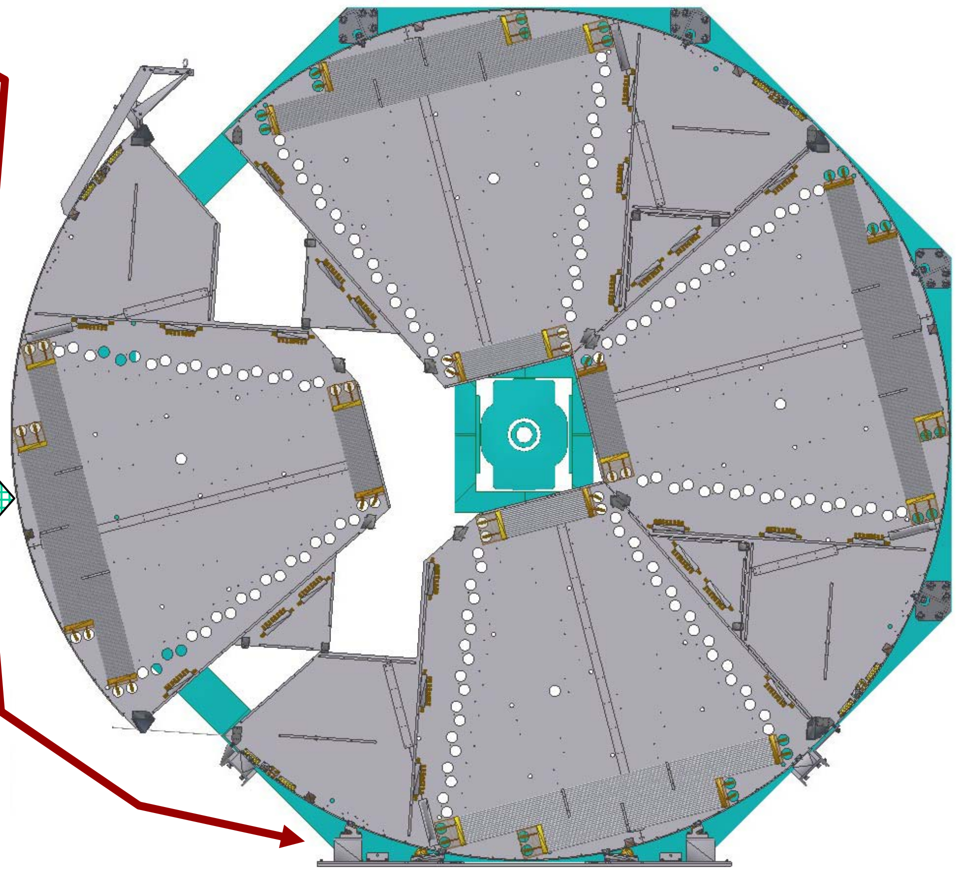
# Installation



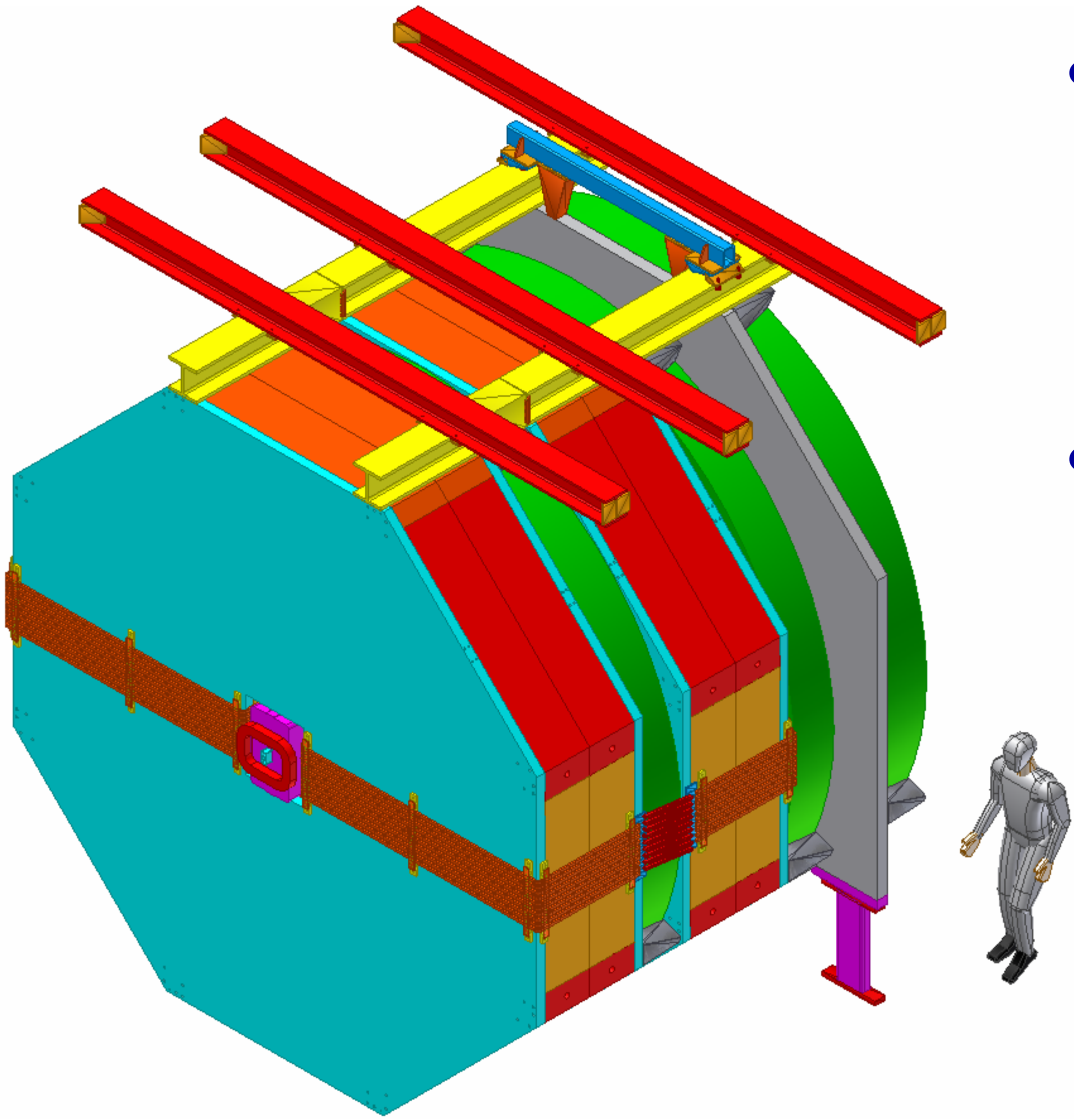
- "Vertical Lazy Susan" installation - rotate during installation on floor rollers

See movie!

- This allows each view to be individually serviced: it will be possible to install and/or remove an octant during run.
- Each octant is installed in wide aisle horizontally.
- Each wheel will then be hung vertically from overhead beams. (next slide…)



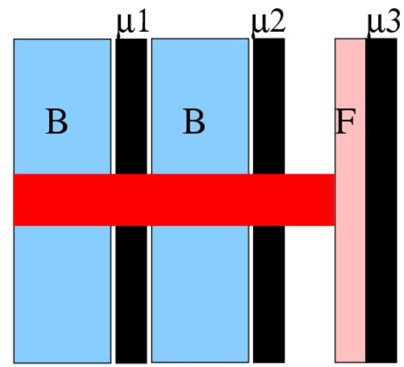
# Overhead Support

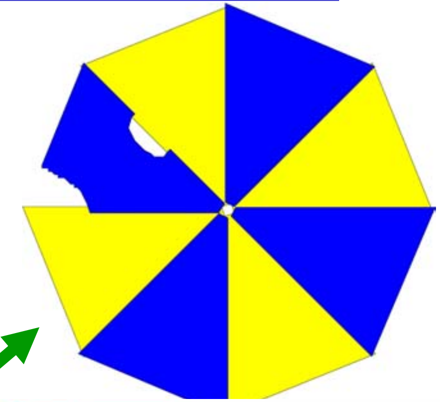


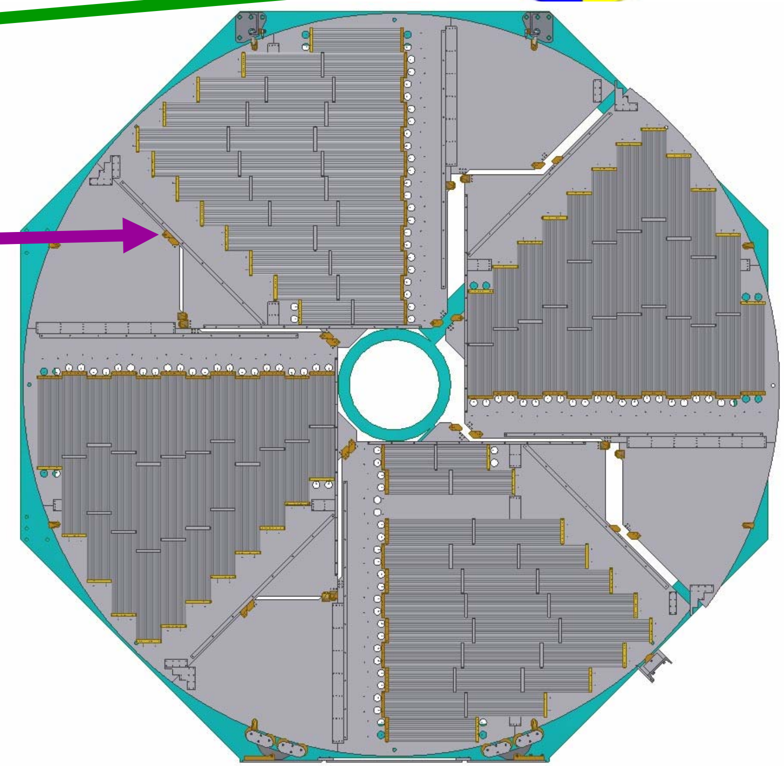
- The entire muon system can move with the toroid package since there are no floor connections.
- The toroid assembly is a separate sub-project (WBS 1.1). We have excellent communication with that project regarding space constraints, installation and integration.

# Numerology

- **Base Numerology**
  - 3 stations
  - 4 views per station
  - 8 octants per view
  - 12 planks per octant
  - 32 tubes per plank
  - Wheel = 4 octants
  - 2 pre-production wheels
  - 16 spare octants





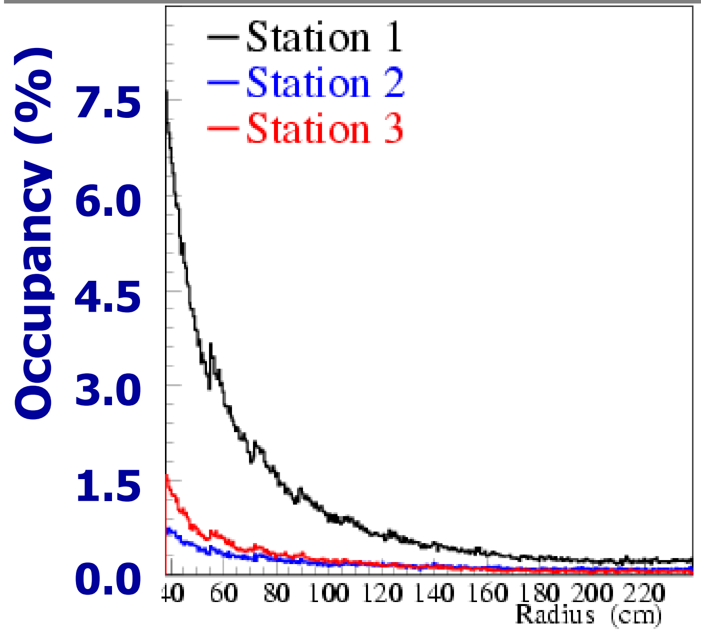
- **For Full Detector:**
  - **36864** channels of tubes
  - **1152** planks
  - **96** quads

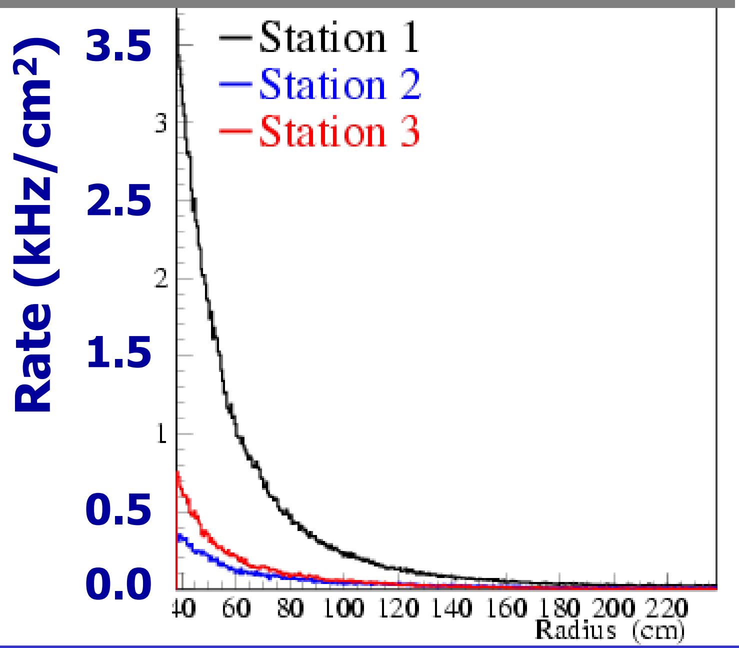
- **Including pre-prod & spares**
  - **46080** channels of tubes
  - **1440** planks
  - **120** quads

# Expected Occupancies

- Minimum bias events will be largest source of hits in detector
- Assuming an average of 6 interactions/crossing

| What | Station 1 | Station 2 | Station 3 | Total |
|---|---|---|---|---|
| avg. # of hits per crossing | 126 | 24 | 27 | 162 |
| avg. occupancy | 1.01% | 0.18% | 0.21% | 0.45% |
| max. channel occupancy | 7.50% | 0.72% | 1.56% | |
| max. channel rate (kHz/cm^2) | 3.7 | 0.4 | 0.8 | |



# Organization

Base cost, fully burdened, in FY05 dollars:

$4.4M (M&S: $3.2M, Labor: $1.2M)

**WBS 1.5 – Muon**
Will Johns & Paul Sheldon

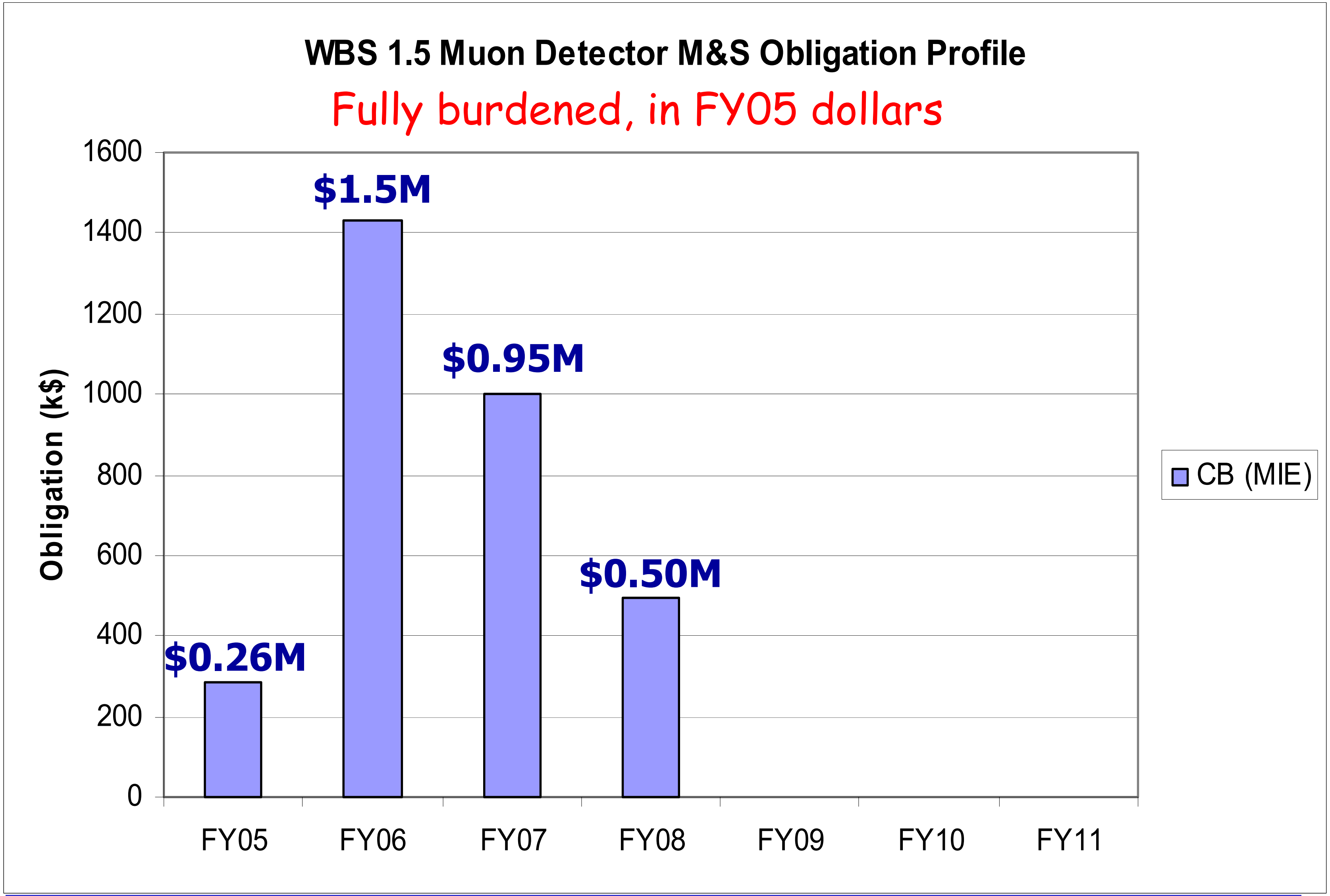
- **1.5.1 Planks** – Paul Sheldon
- **1.5.2 Detector Stations** – Jim Wiss
- **1.5.3 Electronics** – Will Johns
- **1.5.4 Test Stands** – Will Johns
- **1.5.5 Gas System** – Angel Lopez
- **1.5.6 Software** – Eduardo Ramirez
- **1.5.8 SubProject Mgmt**

# Construction Cost

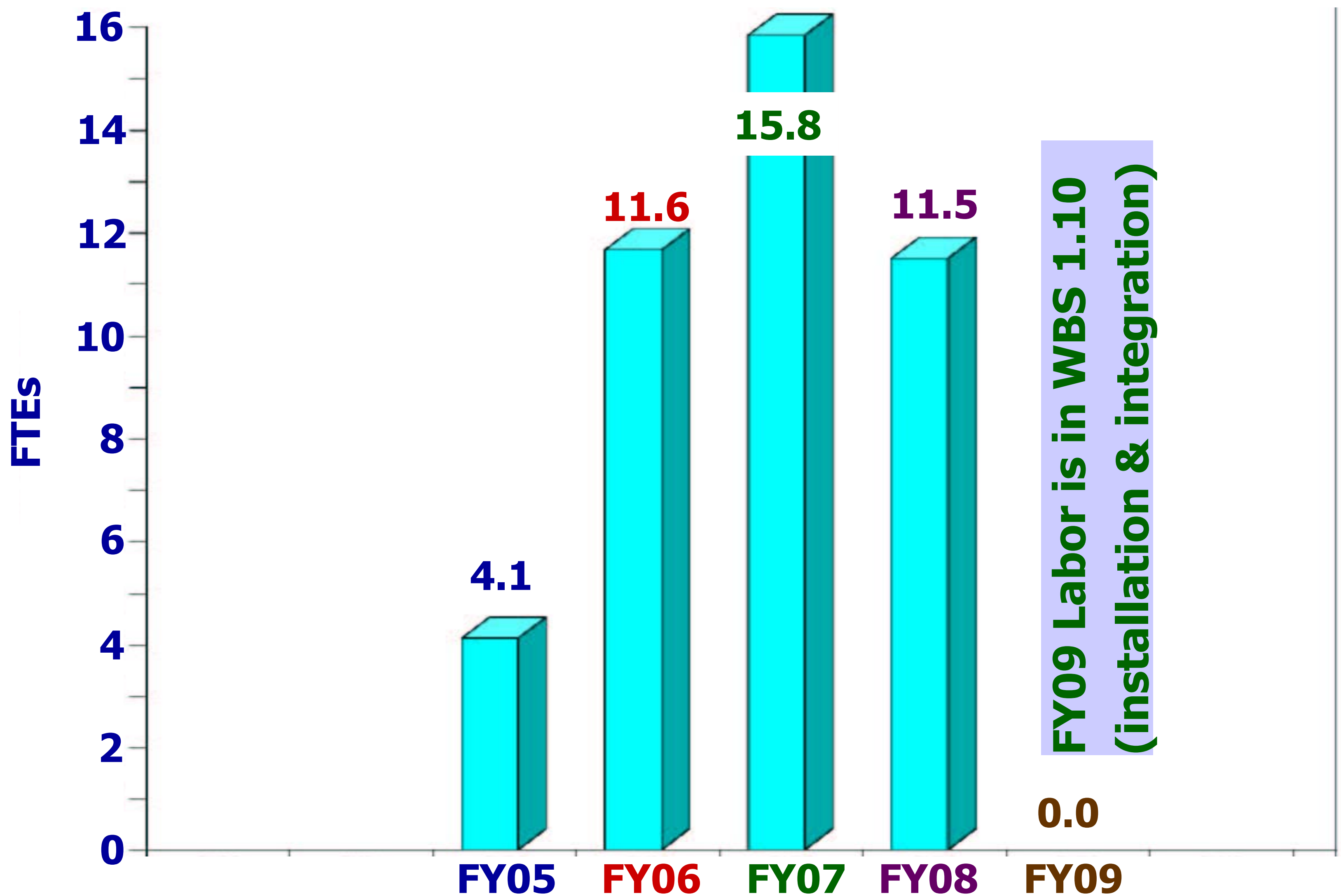
## Fully burdened, in FY05 dollars

| Activity ID | Activity Name | Base Cost ($) | Material Contingency(%) | Labor Contingency(%) | Total FY05 | Total FY06 | Total FY07 | Total FY08 | Total FY09 | Total FY10 | Total FY05-10 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1.5.1 | Muon Detector Planks | 1,788,686 | 43 | 35 | 224,448 | 1,038,534 | 947,131 | 309,512 | 0 | 0 | 2,519,625 |
| 1.5.2 | Muon Detector Stations | 350,771 | 40 | 35 | 63,436 | 330,190 | 52,498 | 41,013 | 0 | 0 | 487,136 |
| 1.5.3 | Muon Detector Electronics | 1,342,152 | 41 | 17 | 40,118 | 885,865 | 415,790 | 510,614 | 0 | 0 | 1,852,387 |
| 1.5.4 | Muon Detector Test Stands | 156,726 | 45 | 50 | 65,448 | 42,949 | 119,421 | 0 | 0 | 0 | 227,818 |
| 1.5.5 | Muon Detector Gas System | 121,319 | 50 | 0 | 0 | 106,050 | 66,903 | 0 | 0 | 0 | 172,953 |
| 1.5.6 | Muon Detector Software | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 1.5.8 | Muon Detector Subproj Mgmt | 600,916 | 24 | 24 | 30,262 | 238,882 | 238,882 | 238,882 | 0 | 0 | 746,907 |
| | | | | | | | | | | | |
| 1.5 | file_15_07Dec04 | 4,360,570 | 41 | 28 | 423,711 | 2,642,470 | 1,840,623 | 1,100,021 | 0 | 0 | 6,006,826 |

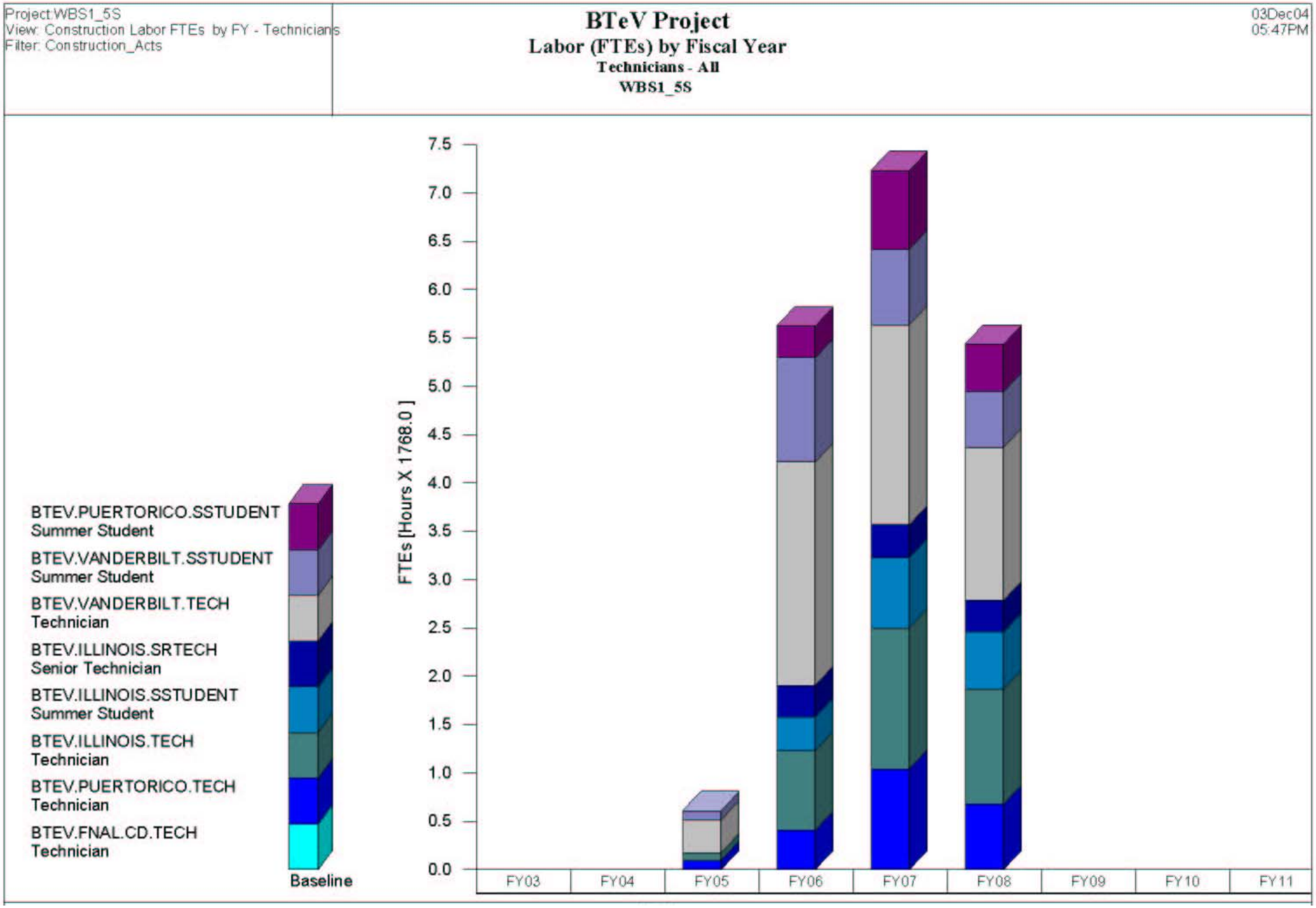
# M&S Cost Profile by Fiscal Year



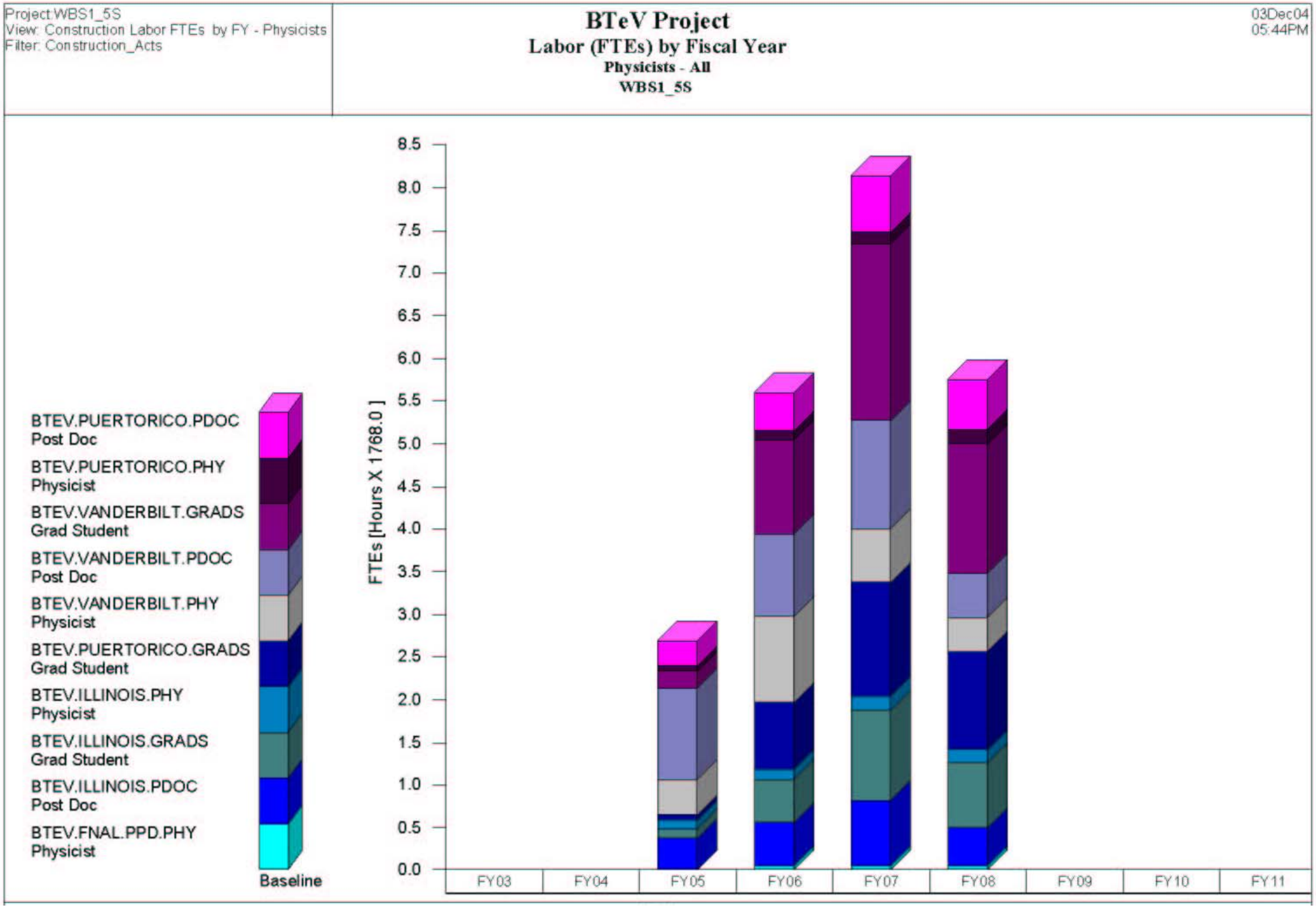
# Labor Profile by Fiscal Year



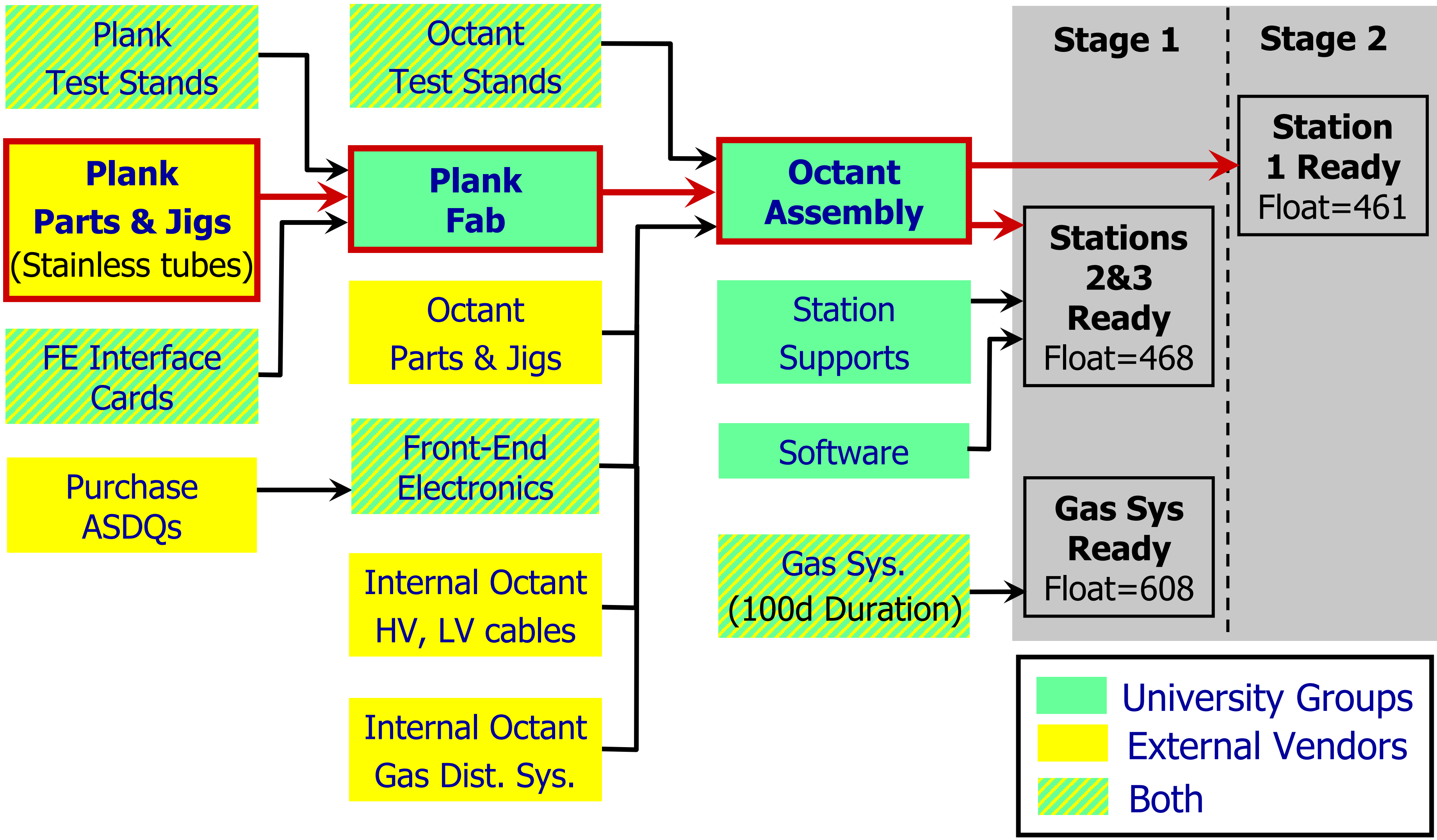
# Technical Labor Profile by Fiscal Year



# Physicist Labor Profile by Fiscal Year



# Description of Project Flow

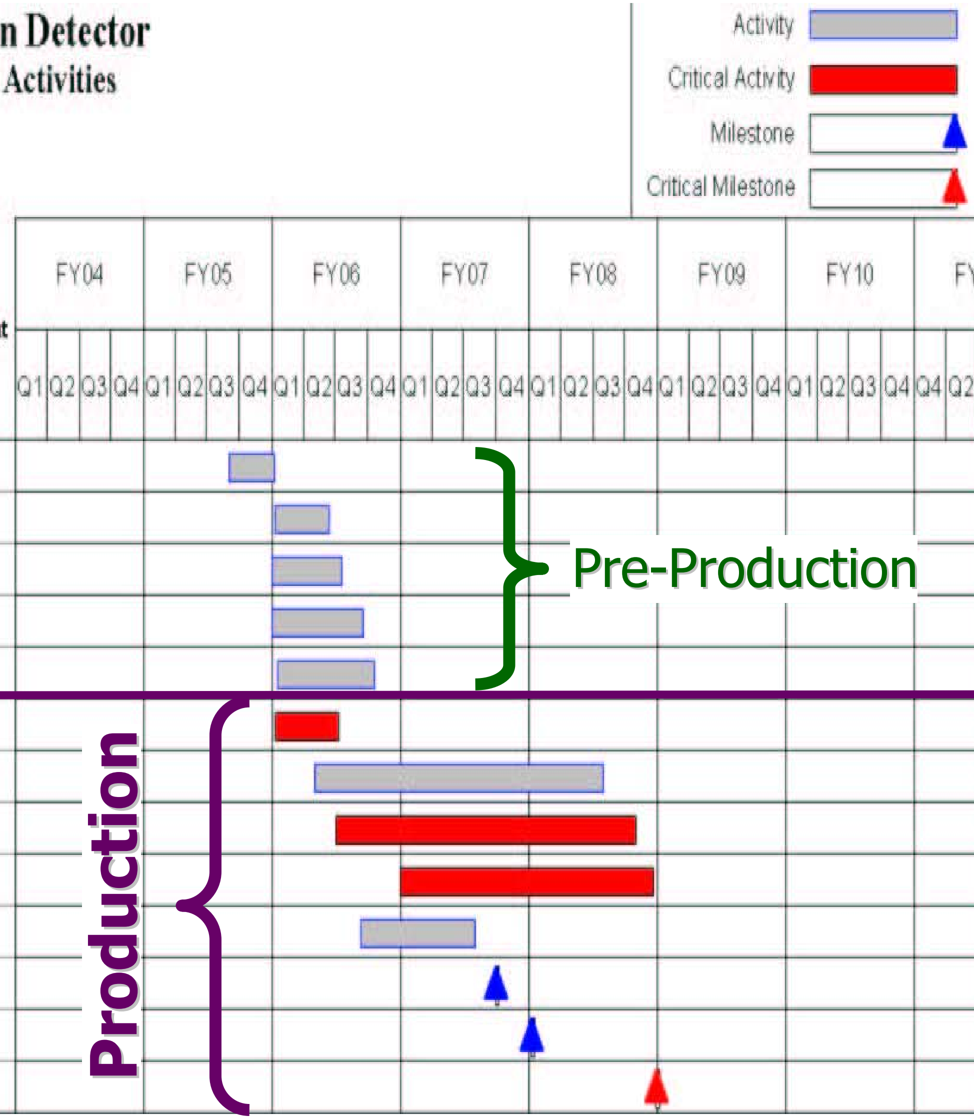


# Key Milestones

## BTeV - WBS 1.5 Muon Detector

### Selected Key (Critical) Activities

| WBS | Activity Desc. | Total Float |
|---|---|---|
| 1.5.1.2.1.3.1 | Manufacture & Del of Pre-Prod Stainless Tubes | 471 d |
| 1.5.1.4.1.1 | Fab Of Pre-Prod Planks at Illinois | 486 d |
| 1.5.3.1.5.13 | Acquisition of ASDQs | 503 d |
| 1.5.3.1.5.3 | Front-End Boards Pre-Prod (VANDERBILT) | 503 d |
| 1.5.2.4.1.2 | Fab Of Pre-Prod Octants at Illinois | 694 d |
| 1.5.1.2.1.3.2 | Manuf & Del Prod Stainless Tubes (1st Ship - 50%) | 468 d |
| 1.5.1.2.6.2.4 | Manufacture & Del of Prod Machined Plank Parts | 480 d |
| 1.5.1.4.1.2 | Fab Prod Planks at Illinois | 468 d |
| 1.5.2.4.2 | Fab Muon Octants at Vanderbilt | 468 d |
| 1.5.3.1.5.10 | Front-End Boards Prod (VANDERBILT) | 503 d |
| 1.5.9.1.3.1 | Lk4M: First Muon Station Ready | 538 d |
| 1.5.9.1.3.2 | Lk4M: Second Muon Station Ready | 468 d |
| 1.5.9.1.3.3 | Lk4M: Third Muon Station Ready | 461 d |



# CD-1 Recommendations

- The primary recommendation was that we hire a full-time quality assurance engineer for the duration of the project.
  - After discussing this with project management, it was decided that additional effort will be added to the project office to handle QA issues for BTeV. The muon project will hire a full-time technician to handle QA and project oversight.
  - We have added this technician to our WBS
- Actively pursue forward funding.
  - Vanderbilt has agreed to provide \$1M in forward funding. Paperwork is in preparation.

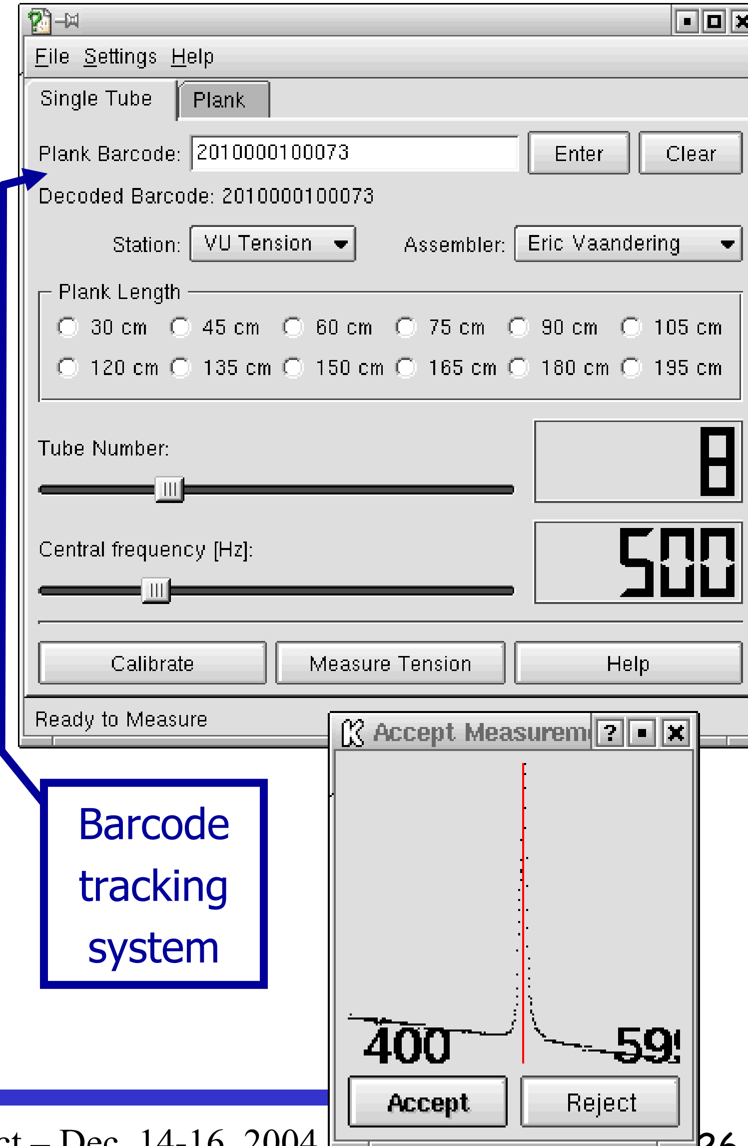
# FY05 Activities

- For FY05, we have scheduled only those Project Engineering and Final Design Activities necessary to keep the project on cost and schedule
- Begin our planned “pre-production” of ~100 planks and 8 octants.
  - Use to shake down our assembly lines and quality assurance programs at each institution
  - Train our QAP technician and assembly personnel
  - Make final design tweaks before production
  - This activity will begin in FY05 but not be complete until 3rd Qtr of FY06
- Costs are for parts needed, assembly jigs and hardware, test stands
  - Only those parts, test stands, etc., that are needed in FY05.
  - Quad test stand not purchased until FY06
- Have $90K in R&D funds from NSF as well.

# Significant Experience

- **We have significant experience w/ many of the steps necessary to build and install the muon system**
  - Built roughly 2 dozen planks, *with student labor*
  - Designed, built and used many of the test stands that we will use in our quality assurance program (tension measurement, etc.)
  - Built a full scale model of one wheel, using it to investigate support and installation issues
  - During the past year, significant engineering on mechanical support structure, now have a well-developed design
  - We have a well-developed design for the Front-End electronics and we have verified its properties with prototypes

**Tension Test Stand**




Barcode tracking system

# Concluding Remarks

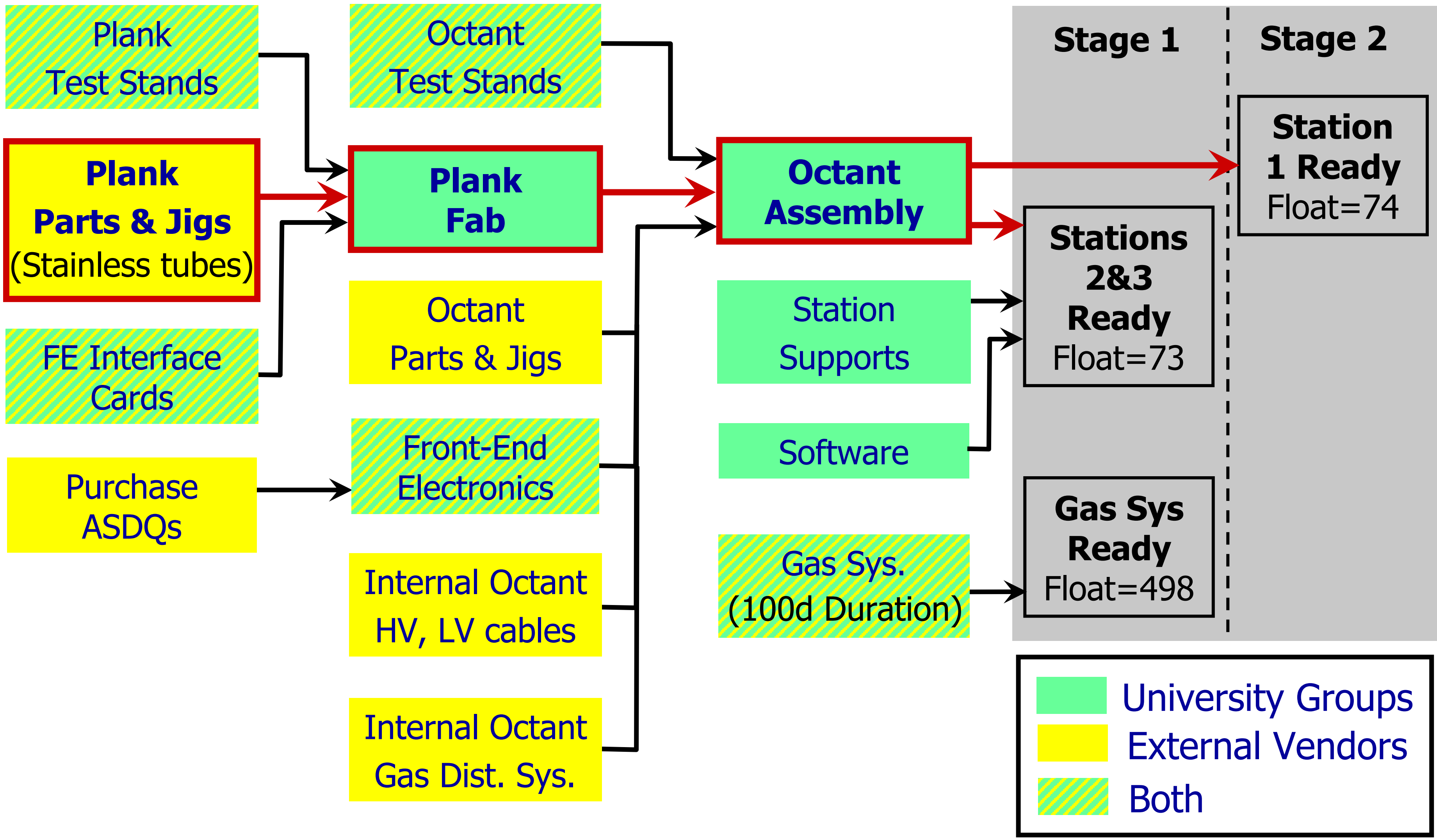
- **We have dealt with many of the vendors we will use**
  - Vanderbilt shop has fabricated the parts it has to make
  - Stainless tube vendors, …
  - Penn ASDQ’s
- **The labor required is modest (43 FTE years) and well-matched to the size of the research groups already on-board.**
  - Physicist (“off-project”) labor reqd is already present in our groups
  - student labor required is not larger than is typically present in each of our groups
- **We have chosen a robust, easy to build, well understood detector technology and our studies indicate that it is well matched to our problem.**
  - This includes a well-developed and engineered design for the mechanical structure and support
- **Technical Design is complete, although we anticipate a few tweaks.**

# …Concluding Remarks

- **We have a well defined and complete Project Cost and Schedule**
  - **Significant float of over 460 days**
- **Sub-project management is in place and capable of performing the project**
- **MOU between Fermilab and Vanderbilt is complete and has been signed by all parties**
  - **Illinois and Puerto Rico MOUs in progress**
- **FY05 Project Engineering and Design work is essential to keeping the project on cost and schedule.**

# The End

# Description of Project Flow With Distributed Float



# Key Milestones With Distributed Float

## BTeV - WBS 1.5 Muon Detector
### Selected Key (Critical) Activities

| WBS | Activity Desc. | Total Float |
|---|---|---|
| 1.2.1.3.1 | Manufacture & Del of Pre-Prod Stainless Tubes | 73d |
| 3.1.5.13 | Acquisition of ASDQs | 283d |
| 1.4.1.1 | Fab Of Pre-Prod Planks at Illinois | 91d |
| 3.1.5.3 | Front-End Boards Pre-Prod (VANDERBILT) | 283d |
| 2.4.1.2 | Fab Of Pre-Prod Octants at Illinois | 511d |
| 1.2.1.3.2 | Manuf & Del Prod Stainless Tubes (1st Ship - 50%) | 73d |
| 1.2.6.2.4 | Manufacture & Del of Prod Machined Plank Parts | 150d |
| 1.4.1.2 | Fab Prod Planks at Illinois | 73d |
| 2.4.2 | Fab Muon Octants at Vanderbilt | 73d |
| 3.1.5.10 | Front-End Boards Prod (VANDERBILT) | 283d |
| 9.1.3.1 | Lk4M: First Muon Station Ready | 318d |
| 9.1.3.2 | Lk4M: Second Muon Station Ready | 73d |
| 9.1.3.3 | Lk4M: Third Muon Station Ready | 74d |
| 5.11.1.3 | Muon Prod Gas Dist Syst | 498d |
| 9.1.3.4 | Lk4M: Muon Gas System Ready | 498d |